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ABSTRACT

This learning module is designed to integrate environmental education into ninth- and tenth-grade chemistry classes. This module and a companion social studies module were pilot tested in Gwinnett County, Georgia in classes of students, many of whom had learning disabilities. It emphasizes activity learning. The module is divided into four parts. Part one is on water sources, part two on water quality, part three on sewage treatment, and part four is a review (the water game). There is a total of 14 activities designed for 14 days. Some of the activities are a field trip to the county water treatment plant, the hydrologic cycle, a cloud formation demonstration, and an investigation of the water table. (BB)

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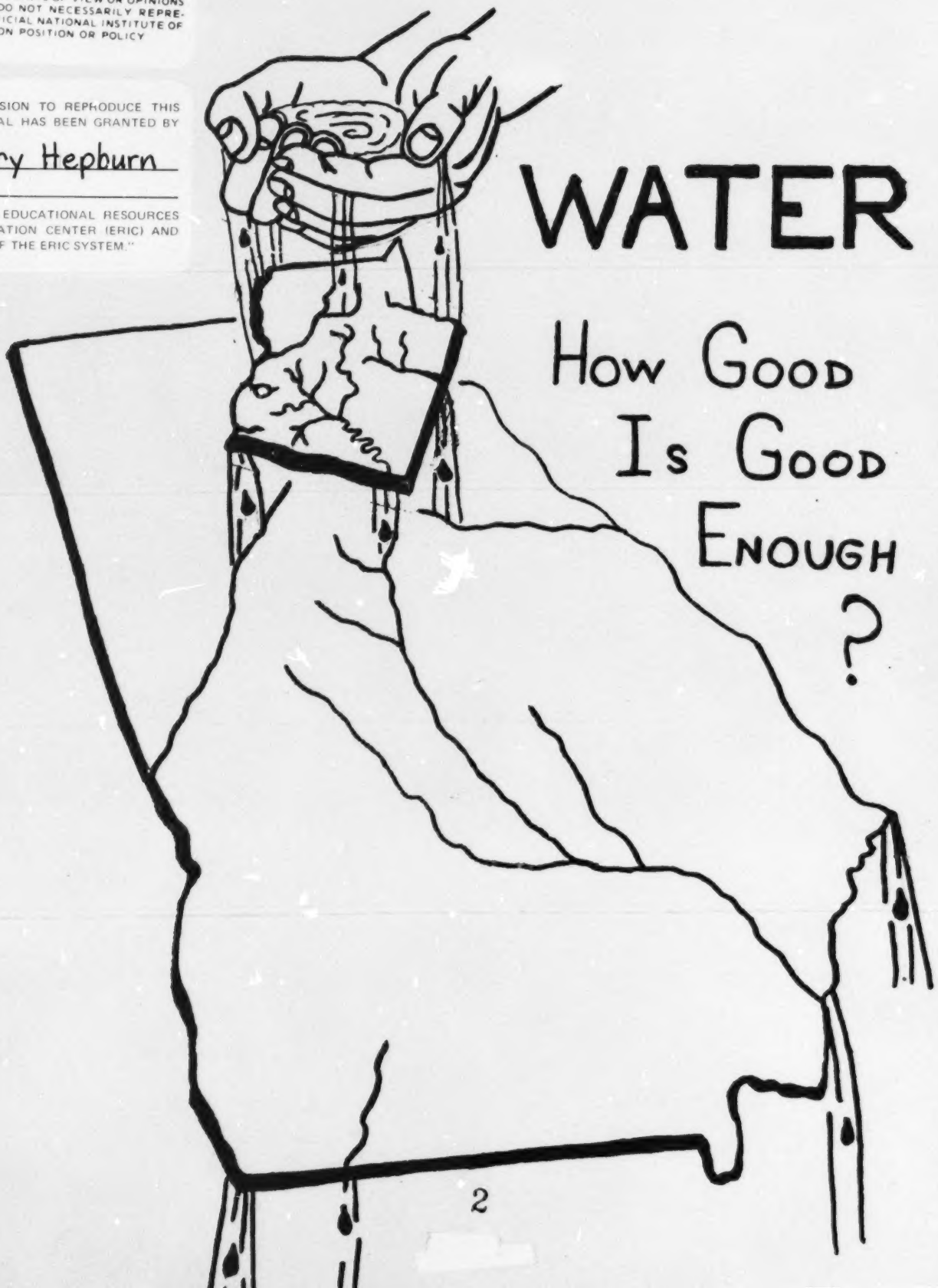
WATER

How Good Is Good Enough?



SE 024 444

WATER: HOW GOOD IS GOOD ENOUGH?

Science Module

Prepared for Pilot Testing in Action Chemistry Classes

Gwinnett County (Georgia) School System

Revised Edition
(9th-10th Grades)

Coordinated social studies and science modules developed by ENVIRONMENTAL EDUCATION FOR THE SECONDARY SCHOOLS, a Curriculum Project of the College of Education of the University of Georgia, supported by the U.S. Office of Education under the Environmental Education Act (Project No. 522AH51215). All rights reserved.

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Environmental Education for the Secondary Schools is a curriculum project which developed these instructional materials to help high school students respond intelligently to environmental policy issues. Utilizing local issues to stimulate interdisciplinary thinking and environmental problem solving, the modular materials are coordinated for social studies and natural science classes.

Project Team

Environmental Education for the Secondary Schools, 1975-1976

University of Georgia Staff:

Mary A. Hepburn, Director and Social Studies Coordinator
John W. Shrum, Science Coordinator
Marsha Scheppler, Social Studies Research Assistant
James E. Nix, Jr., Science Education Research Assistant
Carol Taylor, Science Education Research Assistant

Gwinnett County School District Coordinators and Teachers:

Richard M. Johnson, Director of Secondary Instruction
Betty Bentley, Vice-Principal, Berkmar High School
Kyle Vermillion, Materials Reviewer and Science Teacher
Dianne Bennett, Social Studies Teacher
Lynn Gatlin, Social Studies Teacher
Ruth Lewis, Science Department Head
Ruth Stockel, Social Studies Department Head

Hi!

I'm Environmental Eddie. I'll be here in Gwinnett County for a few weeks while you study local environmental problems.

This module is part of an environmental studies unit you will be studying in your science and social studies classes.

I hope you'll enjoy it and learn a lot too.

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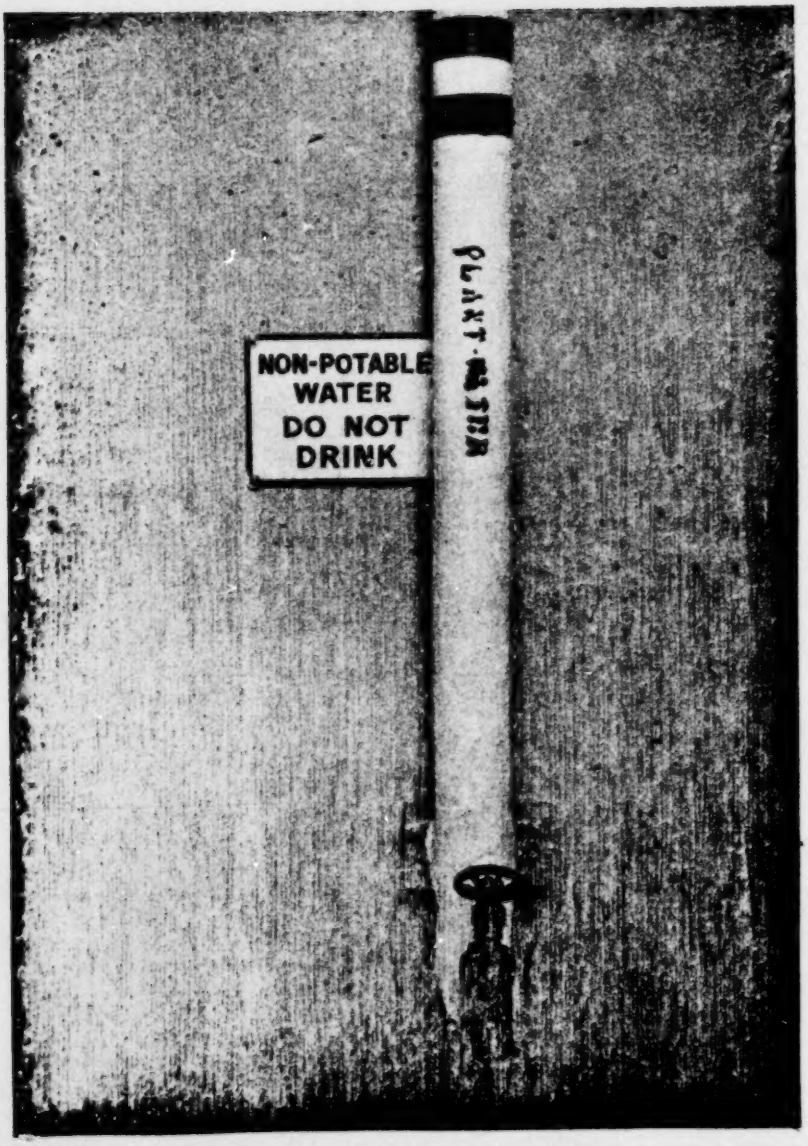
PART I

WATER SOURCES: WHERE DO WE GET OUR WATER?



GWINNETT COUNTY'S WATER

When you take a drink from the school water fountain or fill a glass of water from the kitchen faucet, you probably don't worry at all about whether it is fit to drink.

When you wash your hands or fill the bathtub you probably don't wonder if there is enough water for all the people of this section of Georgia to have baths and showers for years to come.

When you spray water through a hose on your garden or on your car, you probably don't think about where all that water came from.

Very few people stop to think about the source, the quality and the quantity of water they use. Most people assume that we have plenty of water and that it is clean enough to drink when it comes from the tap. But the availability of enough drinkable, usable water is something we should not take for granted.

People are dependent on nature for an adequate supply of water. And man must plan and work carefully with nature to maintain the quantity and the quality of that water. This is a good example of man's interdependence with nature. People must draw the water they need from the earth -- either from its surface or from below the surface. People must then plan ways to obtain an adequate supply to meet their various needs and make that supply of water clean and safe for use.

Activity 1 - Field Trip to the County Water Treatment Plant

Your visit to the Gwinnett County Water Plant should enable you to:

- Identify the sources of the water coming into the plant.
- Describe the water treatment at the plant.
- Compare the quality of the water coming into and leaving the plant.
- Find out how much of the county's water supply comes from this plant.
- Explain how water gets from the plant to the consumer.

The Gwinnett County Water Plant near Duluth is probably the source of the water you use at home -- unless you have a well on the property. This water treatment plant serves most of the residents of Gwinnett County who are on a public water system.

The field trip to the county water plant will allow you to see for yourself where the people of this county get much of their water supply and how that water is prepared for consumers.

While you are at the plant you should obtain as much information as you can to help you answer the following questions:

1. Where does the water at the plant come from?
2. Why does the water have to be treated?
3. In the treatment what materials are removed?
4. Is anything added during the treatment?
5. What records of the water treatment must be kept?

6. What does "potable" mean?
7. What tests are made to determine if the water is potable?
8. How does the water get from the treatment plant to consumers?
9. How much of the water from the plant goes to homes?
   To businesses and industry?
10. How much of the county's water supply comes from this plant?

To answer these questions use notes which you take on the trip and organize it with additional information which you obtain in class.

Field Trip Followup

Most water treatment plants follow a standard process for making the water potable for consumers. The methods used to make the water potable are: sedimentation, filtration, aeration and chlorination.

Sedimentation - The water is pumped into large holding tanks. The heavier material in the water called "sediment" settles to the bottom. Alum is added to the settled water to make the finer sediment settle. (The alum collects around fine particles and make them heavy enough to sink.)

Filtration - The water is passed through sand filters or filters made of layers of sand, gravel and charcoal. This process removes most of the bacteria and the small amounts of fine sediment which remain after the sedimentation process.

Aeration - The water is sprayed into the air to kill the bacteria which cannot survive in oxygen.

Chlorination - Small quantities of chlorine are added to the water to kill remaining bacteria.

Which of these processes are used at the county water treatment plant? What evidence did you see of any of these processes in operation?

Location of the Gwinnett County Water Plant

The large map on the wall in your classroom is a topographic map of the county. This map was pieced together from several smaller maps prepared by the U. S. Geological Survey. The smaller sections are called "quadrangles." One quadrangle, the Norcross quadrangle, is placed beside the Gwinnett county map for you to look at closely. (The scale of miles on these quadrangles is 2 1/2 inches = 1 mile).

A topographic map shows the surface features of the area. It can be a very useful tool for studying the locations of surface features and relationships between these features.

Political (man-made) features and physical (natural) features are shown with symbols and colors on the map. For example, water features are shown in blue. The red lines trace major roads. The spots of purple indicate features added to the map most recently when it was updated from aerial photographs. Areas that are shaded green represent ground cover or vegetation. The brown lines show contour. Contour lines represent altitude or elevation of the land. The brown numbers indicate the elevation of the land above sea level. (e.g. A 1000 foot contour line shows higher land than a 900 foot contour line.) The height between contour lines is 20 feet. If you can find a location where the contour lines are close together, then you can picture in your mind that the slope of the land is steep. What can you say about the slope of the land along the Chattahoochee River?

TOPOGRAPHIC MAP SYMBOLS

VARIATIONS WILL BE FOUND ON OLDER MAPS

Primary highway, hard surface

Secondary highway, hard surface

Light-duty road, hard or improved surface

Unimproved road

Road under construction, alinement known

Proposed road

Dual highway, dividing strip 25 feet or less

Dual highway, dividing strip exceeding 25 feet

Trail

Railroad: single track and multiple track

Railroads in juxtaposition

Narrow gage: single track and multiple track

Railroad in street and carline

Bridge: road and railroad

Drawbridge: road and railroad

Footbridge

Tunnel: road and railroad

Overpass and underpass

Small masonry or concrete dam

Dam with lock

Dam with road

Canal with lock

Buildings (dwelling, place of employment, etc.)

School, church, and cemetery — Cem

Buildings (barn, warehouse, etc.)

Power transmission line with located metal tower

Telephone line, pipeline, etc. (labeled as to type)

Wells other than water (labeled as to type) — Oil — Gas

Tanks: oil, water, etc. (labeled only if water) — Water

Located or landmark object; windmill

Open pit, mine, or quarry; prospect

Shaft and tunnel entrance

Horizontal and vertical control station:

Tablet, spirit level elevation — BM △5653

Other recoverable mark, spirit level elevation — △5455

Horizontal control station: tablet, vertical angle elevation — VABM △95/9

Any recoverable mark, vertical angle or checked elevation — △37.75

Vertical control station: tablet, spirit level elevation — BM ×957

Other recoverable mark, spirit level elevation — ×954

Spot elevation — ×7369 ×7369

Boundaries: National

State

County, parish, municipio

Civil township, precinct, town, barrio

Incorporated city, village, town, hamlet

Reservation, National or State

Small park, cemetery, airport, etc.

Land grant

Township or range line, United States land survey

Township or range line, approximate location

Section line, United States land survey

Section line, approximate location

Township line, not United States land survey

Section line, not United States land survey

Found corner: section and closing

Boundary monument: land grant and other

Fence or field line

Index contour

Intermediate contour

Supplementary contour

Depression contours

Fill

Cut

Levee

Levee with road

Mine dump

Wash

Tailings

Tailings pond

Shifting sand or dunes

Intricate surface

Sand area

Gravel beach

Perennial streams

Intermittent streams

Elevated aqueduct

Aqueduct tunnel

Water well and spring

Glacier

Small rapids

Small falls

Large rapids

Large falls

Intermittent lake

Dry lake bed

Foreshore flat

Rock or coral reef

Sounding, depth curve — 10

Piling or dolphin

Exposed wreck

Sunken wreck

Rock, bare or awash; dangerous to navigation

Marsh (swamp)

Submerged marsh

Wooded marsh

Mangrove

Woods or brushwood

Orchard

Vineyard

Scrub

Land subject to controlled inundation

Urban area

Activity 2 - Topography and The Water System

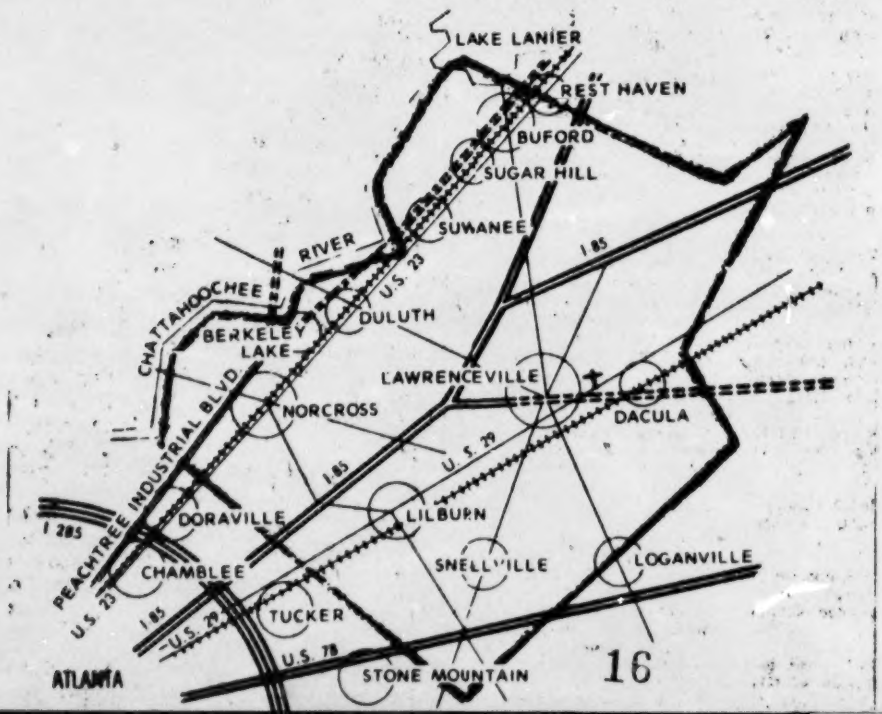
Locate the Gwinnett County Water Plant near Duluth on the topographic map on the wall. Study the location and make notes of the topographic features -- elevation, stream patterns, direction and flow of the water and the locations of towns and cities in the county.

In addition to the water treatment plant near Duluth, Gwinnett County will put into operation in June, 1977, a water treatment facility near Buford. Although Gwinnett County currently uses less than 20 million gpd (gallons per day) the new plant has the capacity for expansion to handle 150 million gpd of water. The new facility will use some of the most advanced engineering techniques available. The treatment facilities are located on Buford Dam Road, south of Shadburn Ferry Road. The raw water will be taken from Lake Lanier and piped three miles to the plant through a 48-inch pipe. Why do you think the treatment facilities weren't located on the lake with the intake plant?

Looking at the map, notice that the elevation lines, stream patterns, and the direction and flow of the water in streams in Gwinnett County seem to follow a pattern. Do you see any relationship between the location of both water plants and that pattern of elevation and stream flow in the county? Explain.

Drainage Map of Georgia

The Eastern Continental Divide runs through Gwinnett County on a line from between Buford and Dacula southwestward to between Norcross and Berkeley Lake. All rivers and all rainfall to the west of the line sheds into the Chattahoochee basin and eventually into the Gulf of Mexico. Rivers and rainfall to the east of the line shed through east Georgia into the Atlantic Ocean. The existence of the continental divide was the main reason for locating the new plant three miles from Lake Lanier, the source of water. The new filter plant is actually located on the Chattahoochee side of the divide, but it is on high ground. Therefore, most water users in Gwinnett County are downhill from the plant and gravitational flow carries the water through the pipes. Water lines are placed down the valleys and only in a few locations are booster pumps needed to move the water up a hill. Even if all electricity is cut off most people can still draw the water left in the storage tanks at the treatment site.

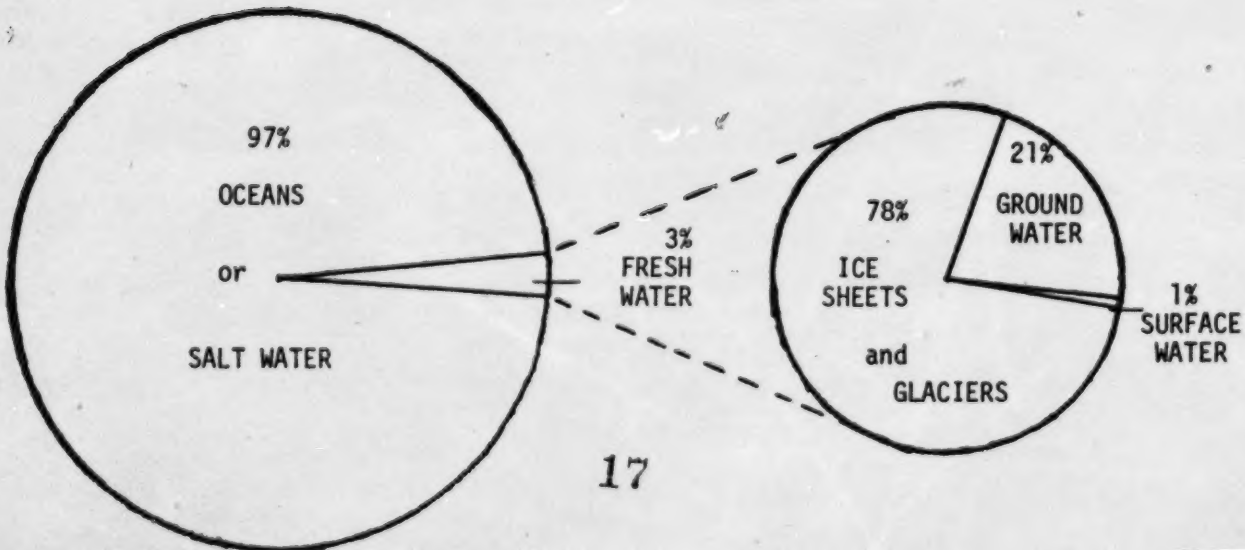


Is Water Here To Stay?

Fresh water is the most important natural resource on earth. Without it life could not exist. The fact that man cannot do anything to increase the amount of water available makes it very important that we use water wisely. To do that we must understand how fresh water occurs and is distributed naturally.

The earth seems to have more water than we could ever need. Water covers about 71 percent of the total earth surface. That seems like a lot of water, and it is. Of all that water, however, only about 3% is fresh water. The other 97% is the salt water of the oceans and seas which is unfit for humans to drink. To add to the fresh water supply problem is the fact that more than three-quarters of the fresh water is locked in glaciers and ice sheets. That leave less than 1% of all the earth's water available on land as either ground water or surface water.

DISTRIBUTION of the EARTH'S WATERS

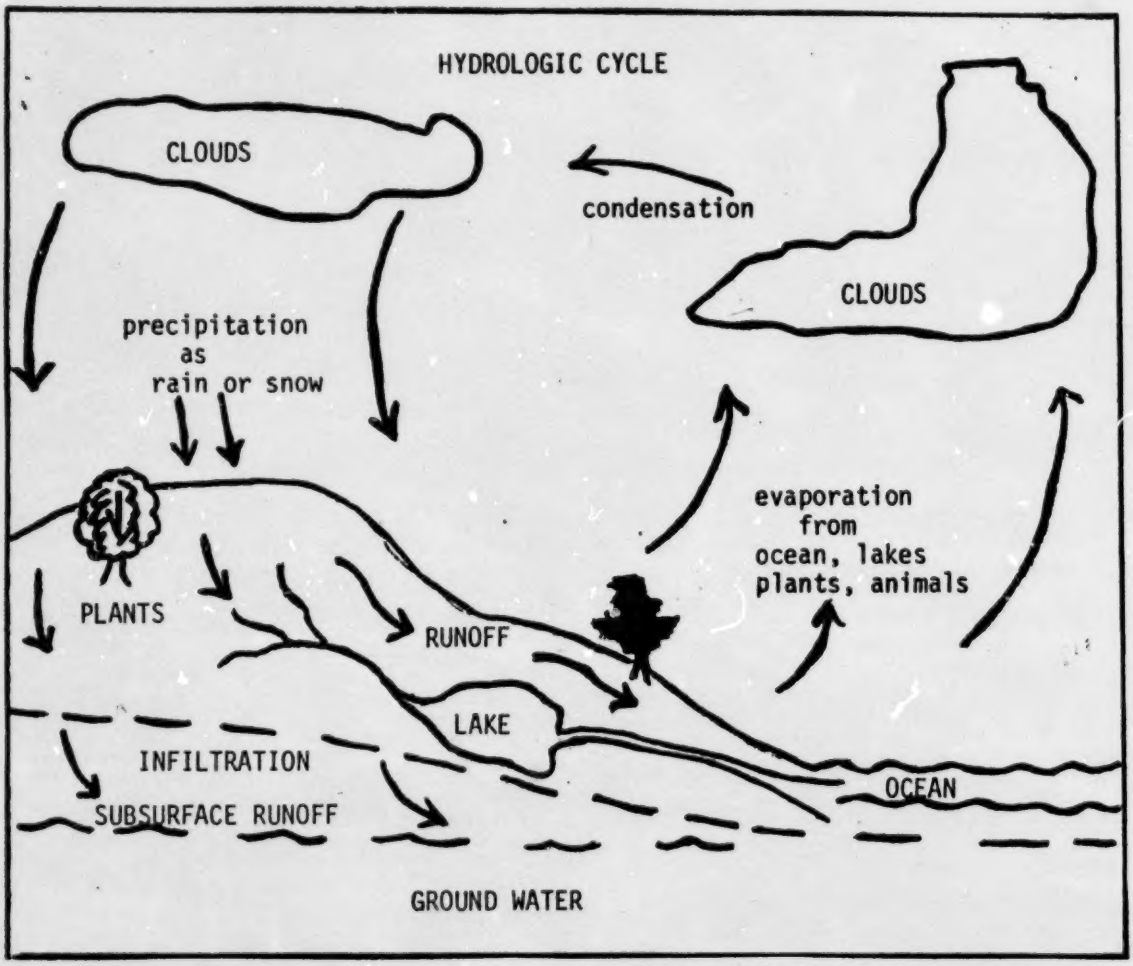


Activity 3 - The Hydrologic Cycle

The surface water available to us is produced by the hydrologic cycle. In this recycling of water, precipitation collects into streams, ponds, lakes and in underground water. These are our major sources of potable water. What is the hydrologic cycle and how does it work?

After studying the hydrologic cycle in class, you should be able to:

- Draw a diagram of the hydrologic cycle
- Compare the amount of fresh water available with the total amount of water on earth
- Describe the condition necessary for clouds to form
- Describe how the hydrologic cycle works
- List the distribution of water within the hydrologic cycle



100% precipitation as rain, hail, sleet or snow
- 70% evapotranspiration
- 22% returned to the oceans in streams and groundwater
- 8% withdrawn and used
  - 3.4% irrigation
  - 3.4% industry
  - .6% municipal

Fresh water is a renewable resource because the water on earth is constantly moving through the hydrologic cycle. The cycle involves changes in the physical state of water (e.g. liquid to a gas or liquid to a solid) rather than chemical changes. The diagram on the previous page outlines the major steps involved in this constant recycling of water.

Large amounts of water are evaporated from the surface of oceans, lakes, and other sources each day. Most of this evaporation is a result of the heating action of the sun. Water is also evaporated from plant surfaces in the "breathing" process of transpiration which is known as evapotranspiration. Ninety percent of the water that evaporates over the ocean falls back into the ocean as precipitation (rain, snow, hail, etc.) The remaining ten per cent moves over land areas and joins water evaporated over land.

All precipitation falling onto the earth's land surfaces eventually returns to the oceans. The route the water takes and the time to complete the cycle can vary. Some of the water percolates down into the soil and rocks to join the groundwater. Some water runs off of land surfaces into lakes and streams. All of this water moves from higher to lower elevations and eventually returns to the oceans, completing the cycle.

Man is dependent on fresh water for survival. At present our major sources of usable water are lakes, streams and underground water. The hydrologic cycle is ultimately responsible for the amount of water available to man. Therefore, an understanding of the cycle is necessary in our study of water and the factors affecting it.

Cloud Formation

All of the surface water on earth is constantly moving from one place to another. Some of the water moves rapidly in streams; some water moves so slowly that you can't see it move. An example of water moving slowly would be evaporation from a lake or water transpired from plant leaves. After water enters the atmosphere through evaporation it continues to move with the air masses. Eventually the water molecules condense into water droplets and form clouds or fog. How much and how fast these droplets form depend upon the amount of water vapor in the atmosphere, the air temperature, the air pressure and the availability of very small solid particles on which the water molecules form. These particles are called condensation nuclei. Observe the demonstration on cloud formation to see the effects of pressure and condensation nuclei.

Activity 4 - Cloud Formation Demonstration

Procedures:

With students assisting, your teacher will perform the demonstration.

1. Place about 200 ml. of tap water in a 5 gallon small-mouth bottle.
2. Stopper the bottle and shake several times.

3. Attach a bicycle or automobile tire pump and pump air into the bottle -- 5 or 6 pump strokes.

4. Observe the inside of the bottle carefully as the pressure is released suddenly by removing the stopper.
5. Discuss your observations with others. Did a cloud form?
6. Repeat procedures 2-5 if you want to make additional observations.
7. Strike 2 or 3 matches, let them burn about half-way.
8. Blow the flame out and quickly drop the smoking matches into the bottle. Stopper the bottle immediately after putting the matches in.
9. Repeat procedures 2-5.

Discuss the following questions:

1. Was there a difference in the cloud formation with and without the smoke in the bottle?
2. How can any difference be explained?
3. How does the formation of a cloud in the atmosphere compare with the cloud forming process in this demonstration?
4. How do you think air pollution might affect the formation of clouds?

The Water Table and Surface Water

Once water falls on the earth's surface it flows from higher to lower elevations forming streams and rivers. Lakes and ponds form where something restricts the flow of the water, such as in a natural basin or low area or where a man-made dam is placed across the stream. Some of the water seeps into the ground and continues to move, but at a much slower rate, from higher to lower elevations.

The water table is the underground area where the rocks and soil are totally saturated with water. Sometimes the water table is very close to the surface. (A spring is evidence that the water table is at the surface.) Sometimes the underground flow of water is found deep within the soil and rock and the water then, is difficult for man to obtain.

Knowledge of the position of the water table and the characteristics of the movement of water within the table is important to man. As you saw in the section on the hydrologic cycle, most of the fresh water available to man is underground water.

The quality of the ground water is readily affected by man's activities. Seepage from septic tanks, leaking sewer lines, landfills and dumped garbage will readily contaminate ground water. The location of the water table should always be taken into account when people plan and carry out possible water-contaminating activities.

In certain areas people remove water from the water table to supply their needs. Man can alter the level of the water table by sinking wells or drawing water from springs and other surface sources.

Also,paving, bulldozing and changing the surface contours of the land (e.g. by creating lakes and ponds) -- are activities which will alter the amount of water entering the water table.

Activities which loosen the soil and increase the rain runoff also increase erosion. Rainwater carries loose materials into bodies of water. Oil, fertilizers, insecticides, garbage, soil particles, and many other substances are carried into bodies of water by surface runoff. These substances affect the quality of surface and ground water.

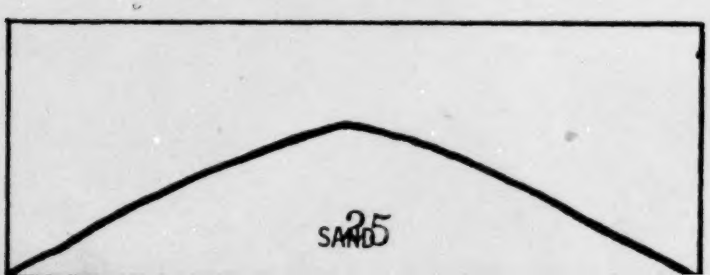
As you saw earlier in Part I, Gwinnett County gets water for distribution from surface sources. Only those people living in rural areas of the county get their water from ground sources (wells and springs.) The following activity should help you to understand how the water table is formed and the effects of surface runoff on ground and surface water sources.

Preparing to Investigate the Water Table

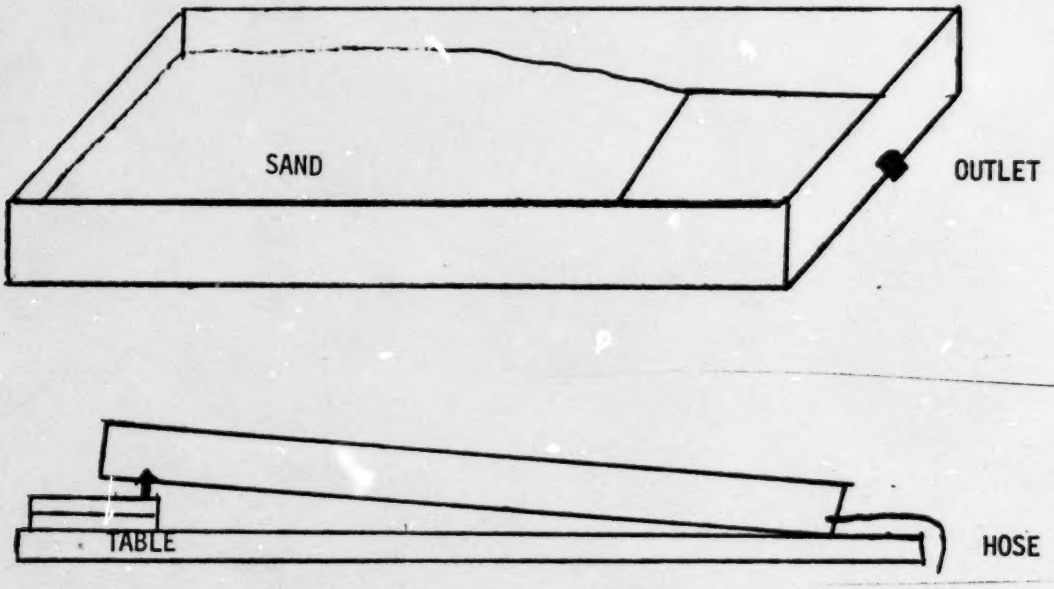
In preparation for an investigation of some of the problems of obtaining a water supply from underground water, you will need to set up the following equipment at each table in the classroom: an aquarium, dry sand, beaker and water.

Follow the instructions below.

1. Place a mound of dry sand in an aquarium so that the sand hill surface slopes from the center to the ends similar to the diagram.



2. Set up a stream table with 2 to 3 inches of dry sand in about 2/3 of the stream table.



Activity 5 - The Water Table and Erosion

A. Using the aquarium and sand hill, find answers to these questions.

1. How does the shape of the water table compare with the land surface?
2. Where would be the best place to drill a well on a land surface similar to the model in the aquarium?
3. If you were going to build a house on or around this hill, what specific location would you choose? What factors did you consider in your choice?
4. What effect might a large septic tank or a garbage dump located on top of the hill have on a well located at the bottom of the hill? What effect could this have on you?

Procedures

1. Pour water slowly from a beaker into one spot at the top of the sand hill in the aquarium.

2. Observe the movement of the water in the sand through the side of the aquarium.
3. Stop pouring water when the water reaches the sand at the ends of the aquarium.

B. Using the stream table set up during the last class, find answers to the following questions.

1. Where is the water table along the shore of a lake?
2. Where is the greatest amount of sediment deposited from a stream entering a lake? Give an hypothesis that would be a possible reason why the sediment is deposited where you observed it to be.
3. Does all rainwater on a land surface run into a stream?
4. How do paved areas such as parking lots and roads affect the movement of surface water? Suppose you lived at the bottom of a paved hillside parking lot?
5. How would large paved areas affect the quality of surface water?

Procedures

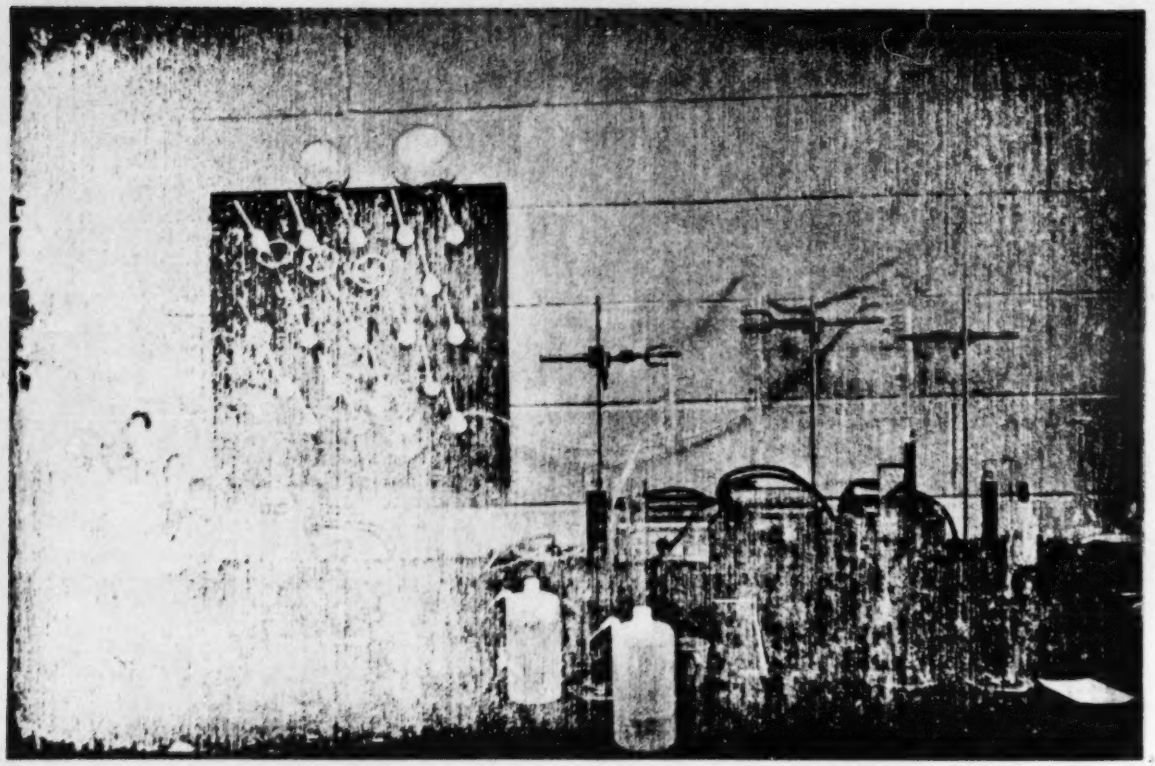
1) Place the stream table so that the end with the opening (outlet) is at the edge of the laboratory table.
2) Elevate the end of the stream table with bricks or boards (books will work, too) so that the end opposite the outlet is about 10 to 12 cm higher than the outlet end.
3) Connect a rubber hose to the outlet pipe with the free end in a bucket on the floor.
4) Pour water from a beaker into a distribution can (can with holes in the bottom) that produces several small streams of water.
5) Allow water to run from the distribution can onto the sand surface at the elevated end of the stream table.
6) Observe the flow of water over the sand surface.
7) Pour water until a "lake" forms at the outlet end of the stream table.
8) Overflow water can be used to recycle (refill the water through the distribution can.
9) Answer questions 1, 2, 3 and 4 on the basis of your observations.

NOTE: You may want to try these procedures several times to see what happens under different conditions. For example, raise or lower the end of the stream table to see what effect the steepness of the slope has on streams and lakes. Increase or decrease the rate of rainfall by using two distribution cans at once and one distribution can with some of the holes covered.

Make observations to answer the questions by placing a sheet of plastic over about half the width of the sand surface and then following the same procedures as before.

PART II

WATER QUALITY: HOW DO WE MAKE IT SAFE TO DRINK?



Water Quality

In the previous section you saw some ways in which contaminants might be added to water sources. The quality of water depends on what the water contains in addition to pure H_2O. Water from natural sources normally contains dissolved salts and gases. Water can readily be contaminated by bacteria, algae, organic material, sediment, or chemicals. These contaminants may occur naturally, but man is responsible for most contaminated water.

Organic matter and chemicals get into streams for untreated sewage and waste products from industry. Fertilizers from home lawns add dissolved minerals to the water supply. Both mineral and organic material collect on paved surfaces and are washed into the water supply by rainfall runoff.

Activity 6 - Is This Water Safe To Drink?

Can we tell if water is safe to drink through our senses of sight and smell? Your teacher will provide you with six beakers of water to examine. When you observe the water samples in this activity you should be able to:

- Point out water samples that would be unsuitable for drinking
- Identify water problems that cannot be solved by observing with sight and smell
- Determine if a water sample contains dissolved solids

Observe using your eyes and nose, but DO NOT TASTE the water. If the water is contaminated, tasting the water would be dangerous to your health.

Record your observations on a chart (similar to the one on the next page) which your teacher will hand out. Do not write in this book.

OBSERVATIONS - ACTIVITY 6

Sample No.	COLOR	CLARITY (Turbidity)	SUSPENDED MATTER	SEDIMENT	ODOR	OTHER
1						
2						
3						
4						
5						
6						

(Use for making ditto masters)

From your observations, which samples are definitely not safe (or suitable) for drinking?

1. Which observations helped most in making these decisions?
2. Do you need more information about any of the samples before deciding if they are potable or not? If so, which ones?
3. What additional tests should be run to be sure that you have made the right decision about whether the water is safe to drink?

A simple test can be run to determine if any of the water samples contain dissolved salts or other dissolved materials. You can test for dissolved salts by placing 10 ml. of each sample in a clean watch glass. Allow the water to evaporate overnight (or heat the watch glass to speed up the evaporation).

1. Did all samples have dissolved solids?
2. Which samples had the most dissolved solids?
3. Can you identify what the dissolved materials are?

MARINA OWNERS SAY THEY KEEP LAKE CLEAN BECAUSE IT'S THEIR LIVELIHOOD
But Vandalism Is Still a Problem Around Huge Recreation Area

Activity 7 - The Water Detective: Effect of Chlorine on Bacterial Growth in Water

This investigation will take several days, in order to allow bacteria to grow to the point where we can easily see them. After this investigation you should be able to:

- Describe the effect of chlorine on the growth of bacteria in water.
- Estimate the probability of surface water being contaminated by bacteria.

Procedures

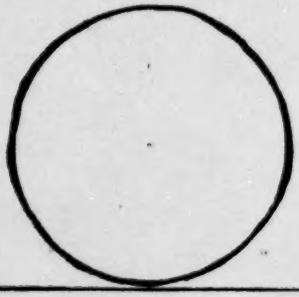
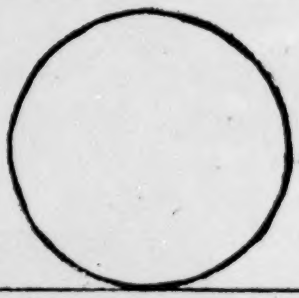
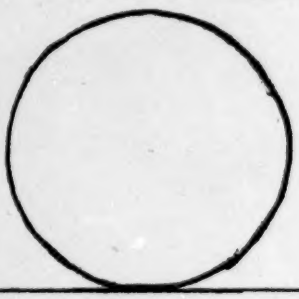
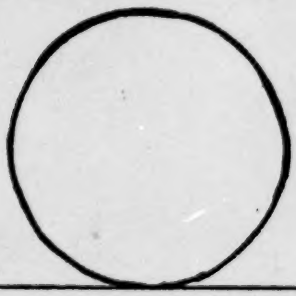
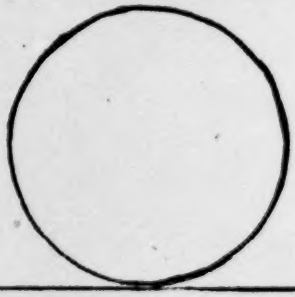
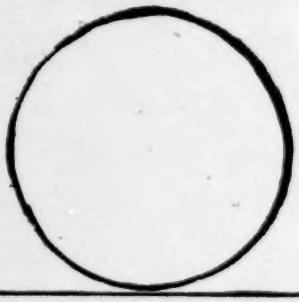
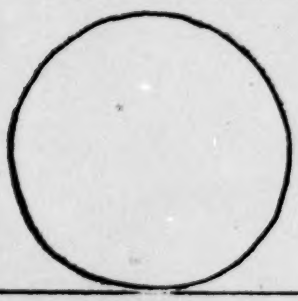
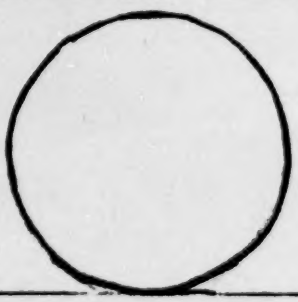
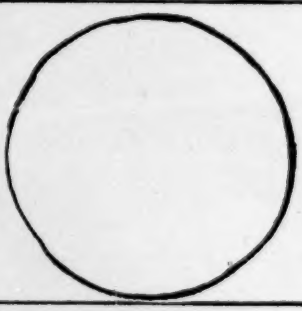
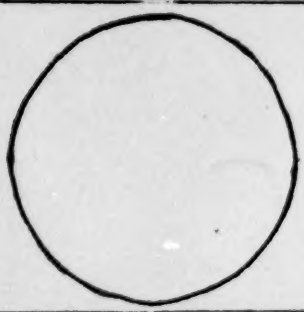
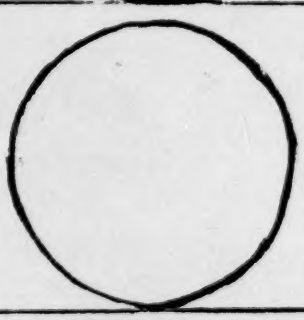
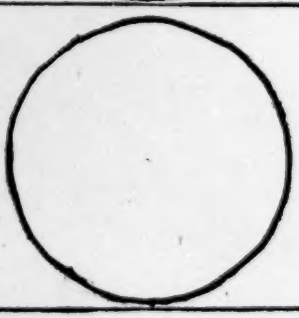
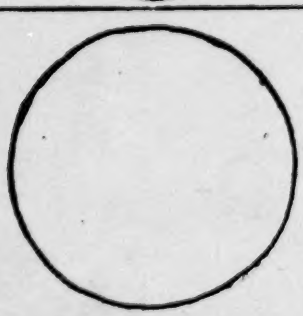
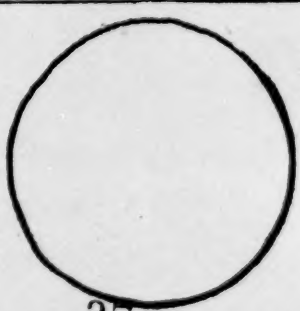
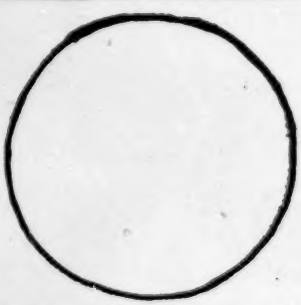
1) Obtain five petri dishes containing sterile, nutrient agar. Keep dishes closed.
2) Label each dish by placing it on a numbered sheet of paper.
3) Keep one dish closed at all times for a control. Label it No. 1 and add the word "control" to the numbered paper.
4) Add 4 drops of water from the sample supplied to each of the other four dishes. (The water is raw water from a stream -- DO NOT TASTE!) Replace cover immediately.
5) Number 2 dish, water only, leave covered.
6) Add 1 drop of chlorine solution to dish No. 3.
7) Add 2 drops of chlorine solution to dish No. 4.
8) Add 3 drops of chlorine solution to dish No. 5.
9) Keep dishes covered and place them where they will not be moved for several days.
10) Record the bacterial growth that you observe over the next several days on the special observation sheet provided by the teacher. Do not write in this book.

Make your observations over at least four days. Then answer the following questions.

1. Which dish had the greatest amount of bacterial growth?
2. Did any bacteria grow in the control dish?
3. Were there noticeable differences in the dish with 1, 2, or 3 drops of chlorine solution?
4. What amount of chlorine seemed to inhibit bacterial growth effectively?

How does this activity relate to the treatment processes observed on the field trip to the water purification plant? How do you think the bacteria got into the water sample you used? Besides chlorination what other treatment processes do you think should be used on water?

Observations of Bacterial Growth

Sample No. and Contents	24 hrs.	hrs.	hrs.
1. Control			
2. Water Only			
3. 1 drop Cl_2 solution			
4. 2 drops of Cl_2 solution			
5. 3 drops of Cl_2 solution			

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Clearing The Water

Upon completion of this activity you should be able to:

- Explain what flocculation is.
- Give reasons for using the flocculation process in treating water and sewage.

Untreated water and sewage often contain suspended materials which cause the fluid to look cloudy. A liquid containing much material is described as being turbid. (Turbid means cloudy.) One of the problems involved in the purification water and the treatment of sewage is the removal of this suspended material.

If water or sewage is allowed to stand undisturbed, some of the suspended matter will sink to the bottom. The smaller, lighter pieces of matter may require a long time before they finally settle out. A turbid liquid can be treated with certain chemicals which cause more suspended material to settle out quicker. Such chemicals are called coagulants. The coagulants form a sticky substance which is called floc. Suspended particles stick to the floc and form larger and larger clumps. These larger clumps usually settle out at a faster rate than individual particles. The process of adding coagulants to a liquid to cause formation of floc and the settling of suspended material is <u>flocculation</u>.

The amount of a coagulant that is added to water or sewage depends on the amount and kind of suspended matter present. Technicians at water and sewage treatment plants from time to time perform experiments to determine the right amount of coagulant to use to get the quickest, most complete settling necessary for current conditions. The formation

of large floc particles may not necessarily give the fastest settling rate.

In this experiment you will find which amount of coagulant gives good floc formation with the fastest and most complete settling. The coagulant will be 1 gm. of aluminum sulfate in 1 liter of solution.

Activity 8 - Flocculation*

This activity will be done in groups of 8. Each group will need 7 beakers (one liter), 6 pipets or graduated cylinders, 7 stirring rods, turbid water sample, and aluminum sulfate solution (1 gm/liter.)

Procedure

1) Number the beakers from 1 to 7. Each member of the group will be responsible for certain beaker(s). Someone should also serve as a time keeper and coordinator.
2) Pour 400 ml of turbid water into each beaker.
3) From the chart below determine how much coagulant should be added to each beaker. (Correspond the number on the beaker to the one on the chart.)
4) All members of a group add the aluminum sulfate solution at the same time.
5) Stir vigorously for 2 minutes. Then stir slowly for 8 minutes.
6) Place the beakers aside to set for 20 minutes undisturbed.
7) Observe the beakers at 5 minute intervals. Your teacher will direct you to other activities while the liquid is settling.
8) In your observations note which sample: a) formed floc the fastest, b) formed the most floc, c) formed the least floc, d) formed the largest floc particles, e) settled out the best (was the clearest.)

(*based on an experiment in R.P. Bolton, et al, Laboratory Experiments in Action Chemistry. Holt, Rinehart & Winston, 1973.)

(Record your observations on the data chart provided by your teacher. Do not write in the book.)

DATA CHART

Beaker No.	ML. of Aluminum Sulfate Solution	OBSERVATIONS
1	none (Control)	
2	3.3 ML	
3	6.6 ML	
4	10 ML	
5	13.3 ML	
6	16.6 ML	
7	20 ML	

Discuss your observations:

A) What amount of coagulant would you recommend using? Why?

B) Would the use of the water or destination of the sewage after cleansing affect the amount of coagulant you would use?

C) Should you use filtration before or after this procedure? Why?

D) What would be some disadvantages to using a similar technique to clear sewage or drinking water?

E) How does this activity relate to the treatment processes observed on the field trip to the water purification plant?

F) Besides removing suspended matter, what else do you think flocculation might remove?

Photo By Corps of Engineers

A SAILBOAT FOLLOWS THE WINDS ON CLEANED UP LAKE
Upgraded Sewerage Treatment Helps Keep Waters Blue

Activity 9 - pH and Floc Formation *

After completing this activity you should be able to:

- Explain why operators of water or sewage treatment plants would be concerned with the pH of incoming fluids.
- Given a fluid of a known pH, predict changes in the flocculation of the sample according to changes made in the pH of the sample fluid.

In Activity 7 you saw how floc formation and sedimentation can be used to improve the quality of water by removing suspended materials. The samples you used were from the name source and alike in physical and chemical properties. Water or sewage from different sources may contain materials that would react differently to the process of flocculation. Many of the processes in which water is used alter it's pH by adding such things as CO_2, Cl-, and SO_4-.

To determine if the pH of a solution affects floc formation and sedimentation complete this exercise. For this lab each group will need 3 one liter beakers, a graduated cylinder, 3 stirring rods, pH indicator test paper, aluminum sulfate solution (1 gm/liter.) hydrochloric acid 1 M in dropping bottle, sodium hydroxide 1 M in dropping bottle, turbid water (from the same source as the previous activity). Work in groups of four.

Procedure:

1) Pour 400 ml of turbid water into each one liter beaker and label the beakers.

(*based on an experiment in R. P. Bolton, et al, Laboratory Experiments in Action Chemistry Holt, Rinehart & Winston, 1973.)

2) Add 10 drops of 1M HCl to beaker 1. Add 10 drops of 1M NaOH to beaker 2. Keep beaker 3 as a control.
3) Stir beaker 1 with a stirring rod and touch the wet end of the rod to a strip of dry pH test paper. Compare the color of the test paper with the color chart on the test paper container and record the pH. (Leave the stirring rod with beaker 1.)
4) Perform the same test with beakers 2 and 3 and record their pH.
5) To each beaker add the amount of aluminum sulfate solution your team recommended in Activity 7.
6) Stir all the beakers vigorously for 2 minutes. Stir slowly for 8 more minutes.
7) Place the beakers aside to stand for 20 minutes undisturbed. Observe floc formation and settling at 5 minute intervals.
8) While you are waiting your teacher will direct you in other matters.

Discussion:

1. Did a change in pH affect the floc formation or settling? If no, how did these change?
2. Why do you think you got the results you did get?
3. From your observations here, do you think operators of water or sewage treatment plants would be concerned about the pH of the incoming fluid.
4. What procedure would you recommend to change the pH of incoming fluid.
5. What could happen to Gwinnett County's water if quantities of acid were dumped into the Chattahoochee River upriver from the water treatment plant?

Activity 10 - The Gifts

We have studied some of the water problems of Gwinnett County. Erosion of land surfaces has been accelerated by construction of highways, housing developments, shopping centers and farming. Erosion puts sediment into streams and lakes which must be removed to produce potable water. Fertilizers from farms and lawns are dissolved in the water supply. Detergents, sewage, pesticides, decaying plants and solid waste materials such as bottles, plastic, and rubber tires all get into the water supply. These problems must be solved in order to provide safe water now and in the future.

The Gifts is a film from the Environmental Protection Agency. It tells the story of what is happening to the fresh water supply in North America. Most of the water problems in Gwinnett County are also happening near every major city in the world. After seeing and discussing this film, answer these questions:

1. If one fourth of the fresh water in the world is found in North America, why should we be concerned about the pollution problem? Isn't there lots of water that's not polluted?
2. Water that looks clean may still be polluted. What would cause this kind of pollution? How can such pollution be controlled?

3. Heated water from industrial waste water pollutes by disrupting the balance of plants and animals that live in fresh water. What steps could industry take to avoid this kind of pollution?
4. The film points out that thousands of our fresh water lakes are dying ahead of their time. What does it mean when we say "a lake is dying?" What are the economic problems that result from a dying lake?
5. What can you do as an individual to help solve the problems of water pollution? Why should you be concerned about doing anything? Will federal, state and local laws control pollution?

* *

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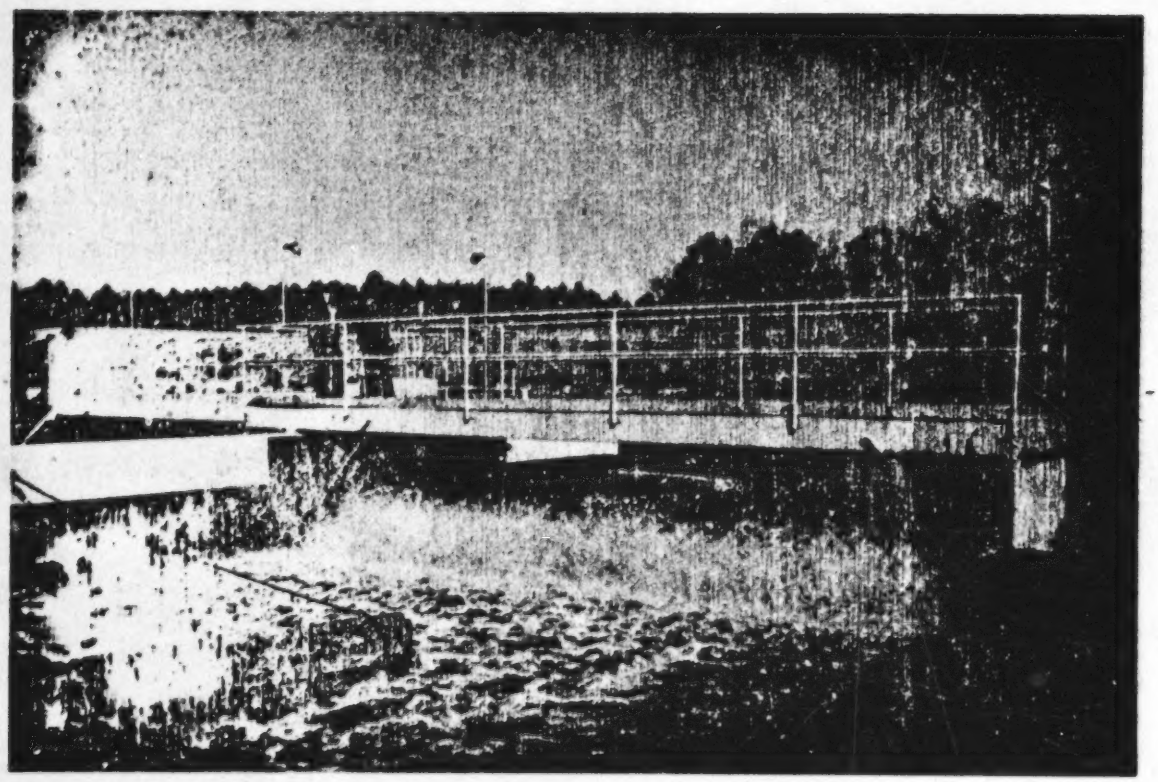
PART III

SEWAGE TREATMENT: HOW DO WE RECYCLE WASTE WATER?



The Treatment of Sewage

After finishing this activity you should be able to:

- Given a diagram of a septic tank tell what process goes on at each point.
- List the 3 types of impurities that affect water quality.

Completely pure water is found only in the laboratory. Even rain water picks up some impurities as it passes through the air. Impurities in water can be grouped into three categories: 1) dissolved chemical compounds, 2) suspended solid particles, 3) organic materials including bacteria, algae, and products of the decayed organic matter Water quality is determined by the amounts of these impurities in the water. Some impurities are welcome because they give to water special tastes or properties useful and pleasing to man.

As water comes into contact with man it often picks up impurities. As the water is returned to the natural environment or later used by man the impurities in the water can be important. Water that has been used by man or has come in contact with man is called waste water. Only within the last few years has there been widespread concern over the quality of waste water that is returned to the natural environment.

Sewage is water containing waste products of human activity and is a type of waste water. Most sewage receives some type of treatment in an effort to reduce or remove impurities. Sewage is most often

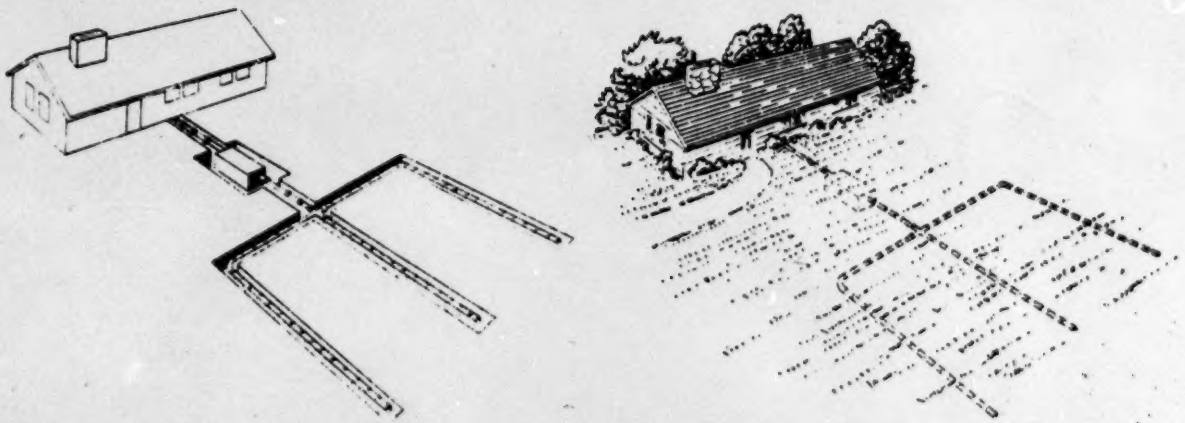
treated in septic tanks or in special treatment facilities. In Gwinnett County 90-95% of the waste water treatment is carried out in septic tanks. A septic tank is located under the ground near an individual house or building to dispose of the sewage formed there. The tank holds the solid waste and allows the liquids to leach out into the surrounding soil.

Within the septic tank itself, anaerobic bacteria decompose some of the organic wastes. Anaerobic bacteria live in an environment with little or no oxygen. If the septic tank system is working properly, the leach lines contain aerobic bacteria which require oxygen for survival. These aerobic bacteria decompose the organic matter dissolved or suspended in the liquid waste. Soil and sediment grains filter out most of the remaining suspended matter as the fluid passes through and out of the leaching field.

If the sewage had been released untreated into some body of water the organic matter would have been acted on mostly by aerobic microorganisms involved in natural decay cycles. To carry out this decomposition the microorganisms require oxygen, but there is only a certain amount of oxygen dissolved in an amount of water. The amount of oxygen that is used up in the process of decomposing organic wastes is the biochemical oxygen demand or BOD. If a septic tank system is operating properly it will remove the BOD, the disease causing organisms, all the phosphorous, and all the suspended solids in returning the water to the groundwater within the natural water cycle.

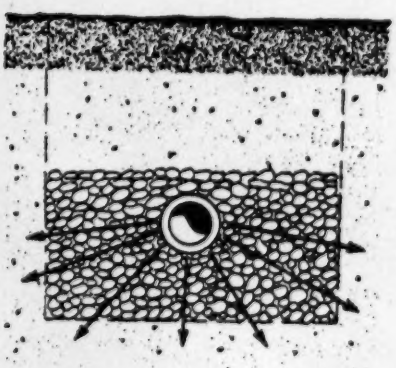
Activity 11 - The Septic Tank As A Primary Treatment

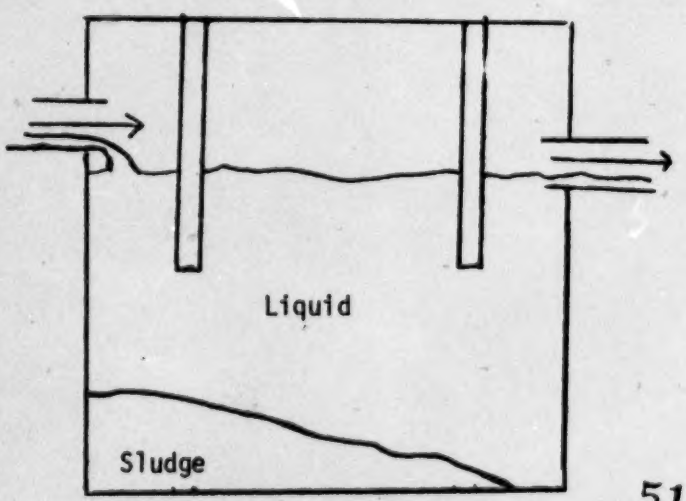
Below is a diagram of a septic tank and leaching field. Look it over carefully as your teacher explains it.



In a conventional septic-tank absorption field, draintile is laid in trenches (above, left). The tank and tile are covered with soil, and the area is planted to grass (above, right). The effluent from the tank is carried through the draintile to all points of the field where it is absorbed and filtered by the surrounding soil (right).

(Diagram above is from Soils and Septic Tanks, Bulletin 349, Soil Conservation Service, U.S. Department of Agriculture.)





to leaching field

Followup

Looking back to Activity 5 in which you observed the formation and shape of the water table, consider the following situation:

George Clearwater owns a country home in a rural area of the county. Recently Polly Purchase bought the adjacent land up the hill from George. Polly has obtained a permit to place a trailer on her land and is seeking permission to install a septic tank beside the trailer.

How could the placement of Polly's septic tank affect George's well? Can you think of some locations where a septic tank could not function properly and should not be allowed?

* * * * * * * * * * * * *

Activity 12 - Biochemical Oxygen Demand (BOD) and Sewage Treatment Plants*

After completing the activity you should be able to:

- Explain what BOD is and why it is an important factor in water quality.
- Given a diagram of a sewage treatment plant tell what process is going on at each point.
- Distinguish between primary, secondary, and tertiary sewage treatment plants according to the waste products removed (the degree of treatment.)

Today we will use milk to represent the organic matter in sewage and yeast as decomposing organisms to study BOD. You will need the following materials to complete this examination: 1 plastic spoon, distilled water, 2 beakers, powdered milk, dry yeast, 1 dropper bottle of methylene blue solution, 2 small graduated cylinders or syringes, 1 stirring rod, 4 test tubes (at least 10 ml.) 1 tube holder, and 1 marking pencil.

Procedure

1) Prepare a sample of milk by slowly adding 1 level teaspoon of powdered milk into 20 ml of distilled water in a beaker.
2) Prepare a sample of yeast by stirring 1 level teaspoon of dry yeast into 20 ml of distilled water. Allow the mixture to stand, then stir again. Be sure the yeast is well mixed and none has settled to the bottom.
3) Using the chart below add the proper amount of milk and water to each test tube. Note that the total amount of fluid in each is the same but that the concentrations of

* Similar experiment in Environmental Science: Probing the Natural World Intermediate Science Curriculum Study, 1972)

milk is different. Add the water to all tubes first, then the milk.

4. Add 20 drops of methylene blue solution to each tube and mix thoroughly. The blue color of this solution indicates the presence of oxygen. In the absence of oxygen this indicator solution is colorless.
5. Add 2 ml of yeast solution to each test tube. Record the time of addition for each tube. Once the timing has begun don't disturb the tubes because shaking will mix air into the liquid.
6. Examine the tubes periodically. Record the time of change for each tube when the blue color has disappeared from all but the surface area. Record your data on a hand-out record sheet. Do not write in the book.

Record Sheet For BOD Activity

	Test Tube	Test Tube 2	Test Tube 3	Test Tube 4
ml of milk	0	.5	3	6
ml of water	6	5.5	3	0
concentration of milk	0%	8.3%	50%	100%
time of mixing				
time of change				
total time for change				

Discussion:

1. Which tube used up the oxygen the quickest?
2. Why was this tube the quickest to use the oxygen?
3. What effects would the dumping of a lot of organic matter (e.g., sewage) have on the organisms present in a stream or lake?

Sewage treatment plants are classified by what they remove from the sewage. Primary treatment plants remove most of the settleable solids and some BOD (by removing organic matter). Secondary treatment removes the remaining BOD. Tertiary treatment removes or reduces dissolved plant nutrients (nitrogen and phosphorous), and minerals as well as many other chemicals. Chlorine is added to the discharge from each plant to kill as much of the remaining bacteria as possible.

A primary treatment plant (or a similar stage of a multipurpose plant) involves the physical removal of solid materials. Procedures such as the ones you carried out in Activities 7 and 8 can be used to aid this process. Secondary treatment depends on the action of aerobic bacteria to decompose organic matter into inorganic compounds. Some type of aeration and mixing system is used to insure that the bacteria have a good supply of oxygen and organic material.

As you saw in Activity 12 the removal of the organic matter and the consequent lowering of the BOD is important. It is also important to remove the inorganic compounds (particularly phosphates and nitrates) that are the products of secondary sewage treatment. Phosphates and nitrates can act as fertilizer which causes algae to increase its growth. This increased growth of algae can be very undesirable. Therefore, some type of

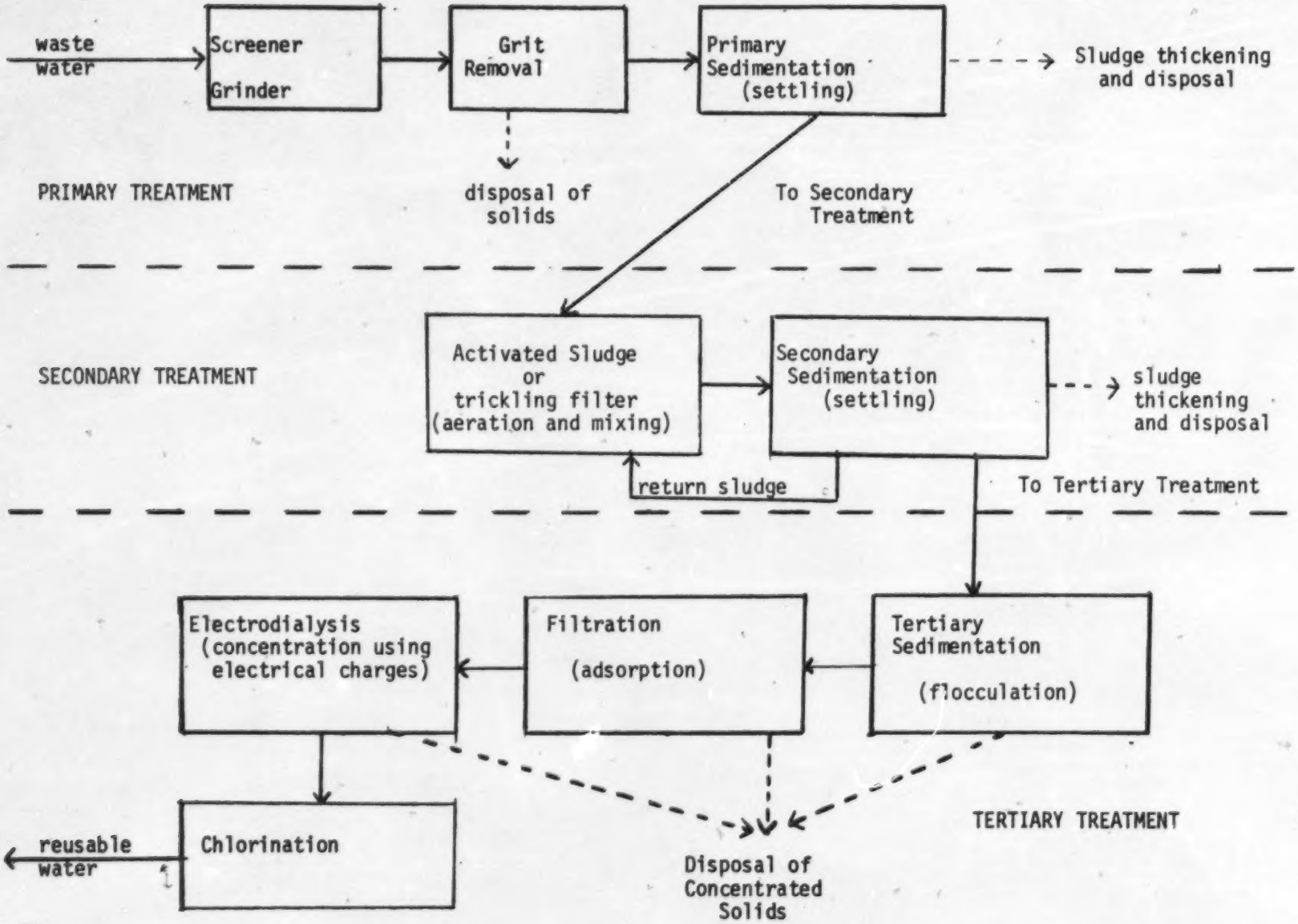
tertiary treatment of sewage is needed in many cases.

Tertiary treatment takes output from a secondary plant and uses coagulation, filtration and concentration by means of electrical charges which remove almost all remaining substances. The discharge from a tertiary plant should be safe to drink and can even be recycled into the water system. Most treatment plants use a combination of primary and secondary treatment. Tertiary treatment is not very common.

Can you think of some reasons why few sewage treatment plants carry out tertiary treatment? Do you think that tertiary treatment offers any hopes for relief of threatened water shortages?

Examine the diagram of a typical sewage treatment plant which is shown on the next page. Your teacher will go over the diagram with you.

A TYPICAL SEWAGE TREATMENT PLANT



Activity 13 - Field Trip To Berkmar School Sewage Treatment Plant

Upon completion of this activity you should be able to:

- Draw a diagram of the school sewage treatment plant giving the process that is going on at each point.
- Identify problems that a facility such as the school treatment plant might have.

This activity will consist of a trip to the Berkmar Sewage Treatment Plant and a discussion of the principles of sewage treatment there. While you are there observe the treatment process carefully. Then, upon returning draw a diagram of the plant showing the important processes going on within the plant. Relate the description of what takes place in the Berkmar sewage treatment plant to the processes you have studied earlier in this course.

Consider these questions:

1. What parts of the plant represent primary and secondary treatment?
2. Why is it necessary to churn the mixture?
3. What would you estimate the quality of water leaving the plant to be?
4. What are some of the most serious problems the sewage treatment plant has to deal with?

Followup

Beside removing organic material, suspended solids and dissolved chemicals from waste water, it is also important to remove harmful bacteria. There are many bacteria in sewage that cause serious diseases in man.

Some of these bacteria are killed in each step in the sewage treatment process. Chlorination is responsible for killing the bacteria that remain after treatment. Only the discharge from a tertiary treatment plant should be free enough of bacteria to be safe to drink. Since few treatment plants use tertiary treatment methods, many bodies of water that receive sewage treatment discharge contain harmful bacteria. Some of this harmful bacteria may survive treatment processes used to purify water for drinking, particularly if the concentration of bacteria is large.

How do you think Gwinnett County might be affected if a town or industry located above the county's treatment plant dumped sewage or some other type of waste water into the Chattahoochee River or into Lake Lanier? Who would be affected if Gwinnett County dumped sewage into the Yellow River, Alcoy River or the Chattahoochee River?

Does Gwinnett County or any user of water have a responsibility to build a waste water treatment plant rather than to dump partially treated or raw waste wate into rivers or lakes? If this county had a county-wide sewer system, what type of treatment facility would you recommend for the system? Why?

THE SEWAGE PROBLEM

Based on what you studied thus far, what is your reaction to each of the following comments on sewage disposal in Gwinnett County. What is the significance of each remark for Gwinnett today and in the future?

"Sewers are gravity fed, so naturally the sewer has to follow the water course. Otherwise we would have to go into great expense to pump the sewage from one point to another. So the policy has been in the past, rather than to pump, to follow the natural water course. All our sewers are laid along water courses. . . . "

****

"Probably 10% of the people [in the county] are on the sewer system. The rest are on septic tanks."

****

"We [Gwinnett County] can provide sewerage service in some manner to almost anyone who wants to come into the county. If a big industry or business concern decides to come in here, or other persons move into the county, it increases the tax base and as that tax base goes up our capability of being able to provide utility services and other municipal services increases also."

PART IV

THE WATER GAME: WHAT WE KNOW ABOUT WATER MAKES A DIFFERENCE

PART IV

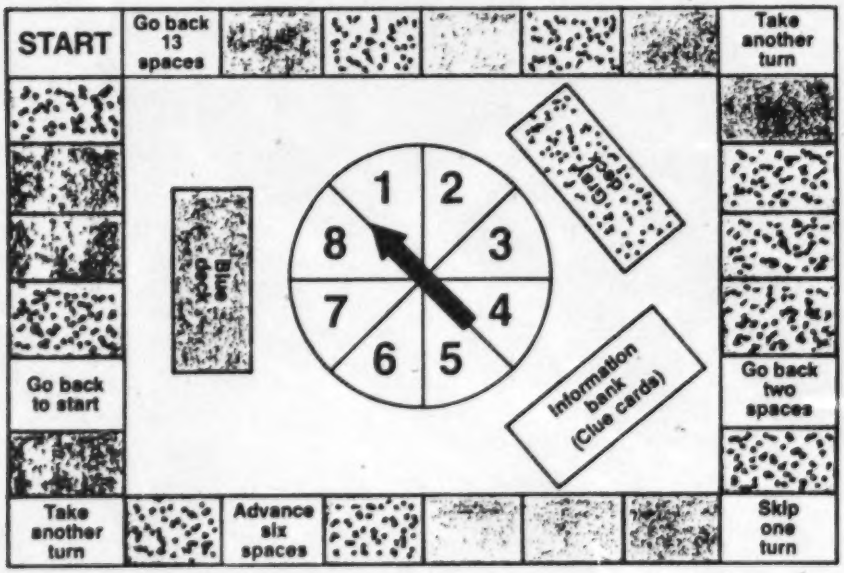
THE WATER GAME: WHAT WE KNOW ABOUT WATER MAKES A DIFFERENCE

Environmental Quest Game

Activity 14

In the Environmental QUEST Game the objective is to answer at least ten questions correctly from the clue cards each player obtains. The first player who returns exactly to the start position with ten or more clue cards wins the game.

The QUEST board has 28 positions with three decks of cards and a spinner as shown below. Colored markers are used by each player to move around the board.



Each player advances around the board according to the rules below. One student is the referee who determines if a correct answer is given from a master list of the questions and answers. Two to six players plus the referee may play the game at one time.

Rules

1. Each player moves the spinner twice to obtain a two digit number. Example: first spin-5 plus second spin - 8 gives the number 58.
2. The player with the highest number is the referee.
3. The player with the lowest number goes first, next lowest goes second and so on.
4. At his/her turn, each player spins and moves their marker the number of spaces indicated by the spinner.
5. Follow directions on the space or if on a colored space select a card at random from the deck of the same color and follow instructions on the card.
6. Whenever a player gets a clue card,he/she tries to answer the question. If the answer is correct according to the referee, the player keeps the card. If the answer is not right, the card is put back into the deck on the board.
7. If a player is instructed to take a card from another player, the card may be taken from any other player and counts as a card for the player now holding it.
8. The first player who returns exactly to the START position with ten or more cards wins the game.

Rules for Scoring A Win

1. If a player reaches or passes START without having ten cards, he/she must go around the board again.
2. If a player lands on the position "Go back to Start" and has ten cards, the player scores an instant win.
3. A player with ten cards must spin the exact number needed to move the marker to START in order to win.
4. If the exact number needed is not obtained, the player may either pass until his/her next turn or back up the number of spaces indicated by the spinner and follow the directions on the new position. If the directions would move the player's marker passed START, the player remains on the new position and returns one clue card to the deck on the board.

(The board, cards and spinner will be provided by your teacher.)